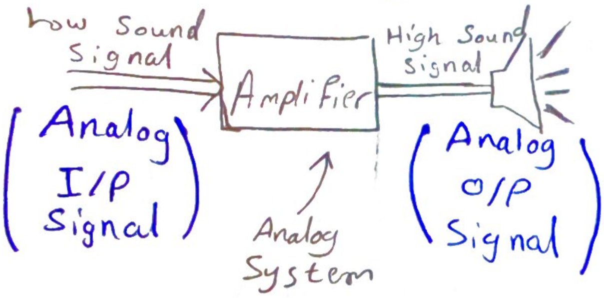
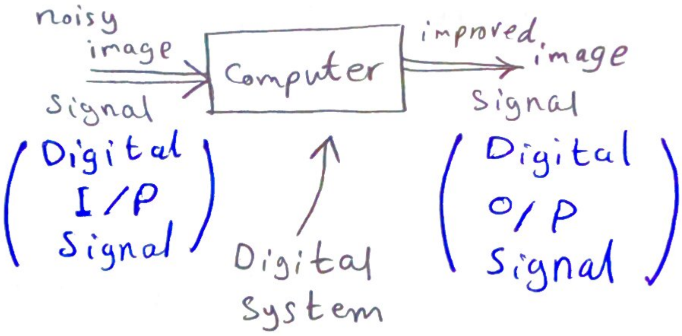
DSP

محاضرة 1 — د. محمد عرفة — الخميس — 1/10/2015

Digital Signal Processing (DSP)

Analog Signal Processing | **Digital Signal Processing**

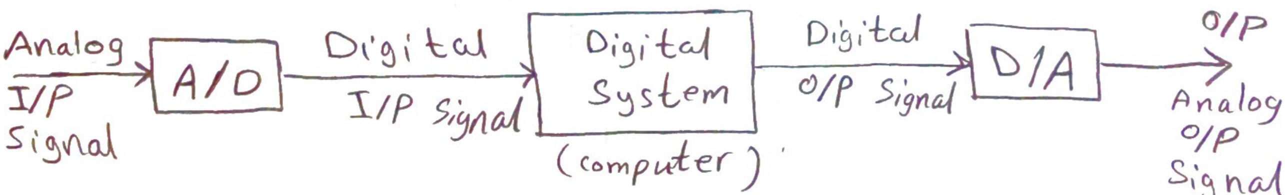




* Advantages of DSP :-

① more flexible
② more Accurate
③ easy to store
④ easy to update

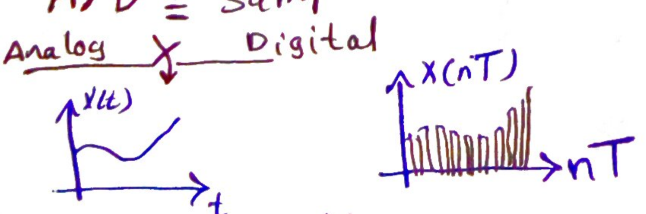
* The Basic elements of DSP :-



A/D ≡ Analog to Digital Converter.

D/A ≡ Digital to Analog Converter.

A/D ≡ Sampler



T ⇒ Sampling time

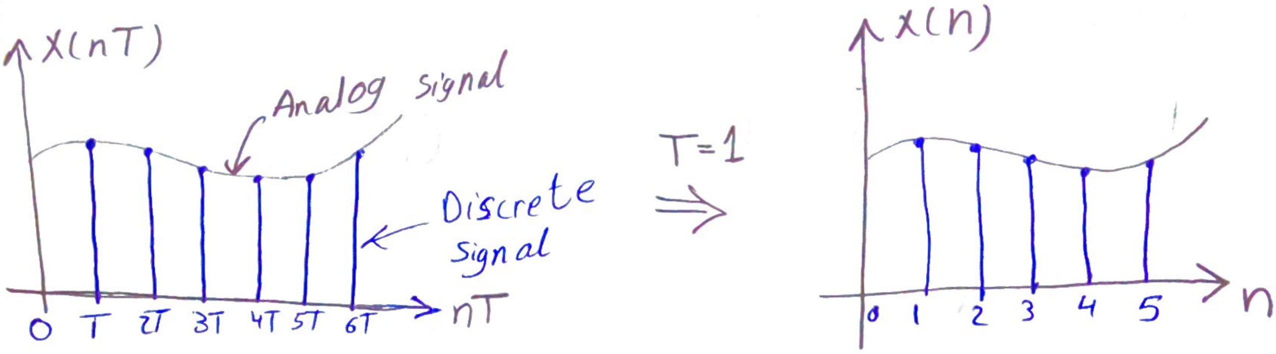
n ⇒ Sampling no. $(n = 0, 1, 2, 3, \dots)$

$$x(nT) = x(t)\Big|_{t=nT}$$

Assume T = 1 sec

$$x(n) = x(t)\Big|_{t=n}$$ (Sampling No.

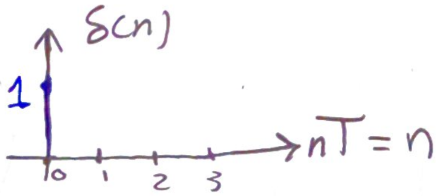
①



* Common discrete signals (sequences)

① unit sample Signal (impulse)

$$\delta(n) = \begin{cases} 1, & n=0 \\ 0, & \text{otherwise} \end{cases}$$

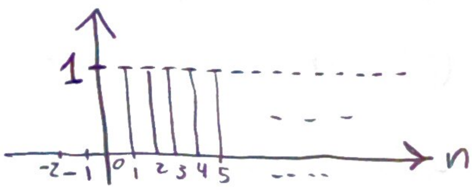


$$\delta(n) = \{ \dots, 0, 0, \underset{\uparrow}{1}, 0, 0, \dots \} = \{ \underset{\uparrow}{1} \}$$

$\uparrow \Rightarrow$ indicates $n=0$

② Unit Step signal

$$u(n) = \begin{cases} 1, & n \geq 0 \\ 0, & \text{otherwise} \end{cases}$$



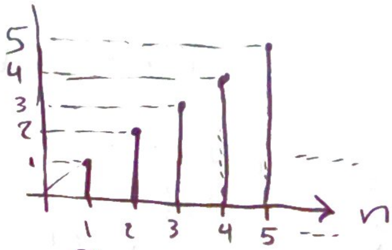
$$u(n) = \{ \dots, 0, 0, \underset{\uparrow n=0}{1}, 1, 1, \dots \}$$

$$= \{ \underset{\uparrow n=0}{1}, 1, 1, 1, \dots \}$$

لو بدون سهم نفهم أن البداية من عند الصفر

③ Unit ramp Signal

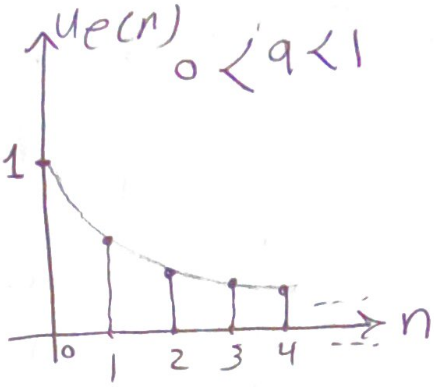
$$U_r(n) = \begin{cases} n, & n \geq 0 \\ 0, & \text{othewise} \end{cases}$$



$$U_r(n) = \{ \underset{\uparrow n=0}{0}, 1, 2, 3, 4, 5, \dots \}$$

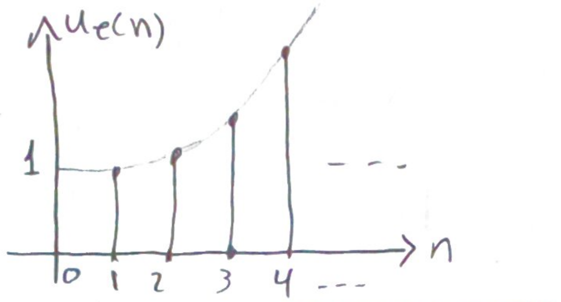
④ Exponential Signal

$$u_e(n) = \begin{cases} a^n, & n \geq 0 \\ 0, & \text{otherwise} \end{cases}$$



$$u_e(n) = \{\underset{\uparrow n=0}{1}, a, a^2, a^3, \ldots\}$$

for $a>1$



Ex: given the following sequence:

$$x(n) = \{\underset{-4}{1/3}, \underset{-3}{1/2}, \underset{-2}{-1}, \underset{-1}{0}, \underset{\uparrow 0}{1}, \underset{1}{1}, \underset{2}{2}\}$$

① Sketh $x(n)$

② Find $x(1)$, $x(2)$, $x(3)$, $x(-1)$, $x(-2)$, $x(-3)$, $x(-4)$

Solution

$x(1) = 1$

$x(2) = 2$

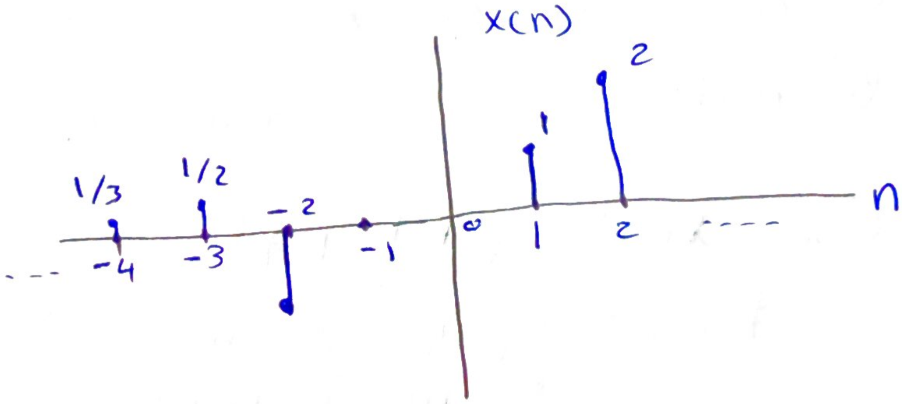
$x(3) = 0$

$x(-1) = 0$

$x(-2) = -1$

$x(-3) = 1/2$

$x(-4) = 1/3$



⟹ Turn over

Ex: Find $\sum_{K=-\infty}^{n} \delta(K)$

$$x(n) = \sum_{K=-\infty}^{n} \delta(K) = \cdots + \delta(-1) + \delta(0) + \delta(1) + \delta(2) + \cdots + \delta(n)$$

$$\left.\begin{array}{l} n=0 \Rightarrow x(0)=1 \\ n=1 \Rightarrow x(1)=1 \\ n=2 \Rightarrow x(2)=1 \end{array}\right\} x(n) = \sum_{K=-\infty}^{n} \delta(K) = u(n)$$

Ex: find $x(n) = \sum_{K=0}^{\infty} \delta(n-K)$

$$x(n) = \underset{\substack{\uparrow \\ n=0}}{\delta(n)} + \underset{\substack{\uparrow \\ n=1}}{\delta(n-1)} + \underset{\substack{\uparrow \\ n=2}}{\delta(n-2)} + \cdots$$

$$= u(n)$$

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* The main operations on discrete Signals :-

1. Shifting operation (delay, Advance)
2. Folding (reflection) operation
3. Add operation
4. multiplicating operation

Ex: $x(n) = \{1, 1, 1, 1\}$

Find : $y_1(n) = x(-n)$

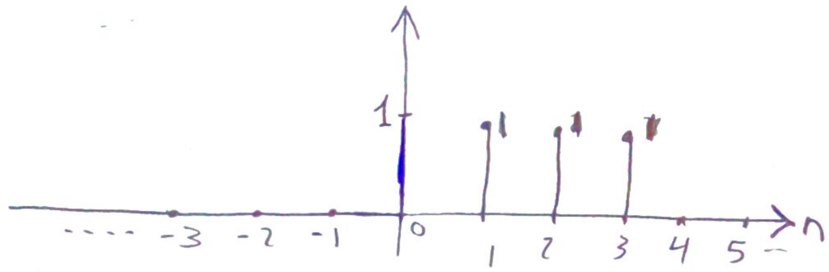
$y_2(n) = x(n-1)$

$y_3(n) = x(n+1)$

$y_4(n) = 2x(n)$

$y_5(n) = x(n-1) + x(n+1)$

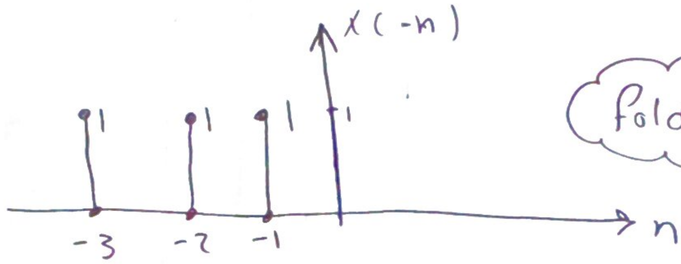
Solution



$\boxed{1}$ $y_1(n) = x(-n)$

$n=0 \Rightarrow y_1(0) = x(0) = 1$
$n=1 \Rightarrow y_1(-1) = x(-1) = 0$
$n=2 \Rightarrow y_1(-2) = x(-2) = 0$
$\vdots \quad \downarrow 0$

$n=-1 \Rightarrow y_1(-1) = x(1) = 1$
$n=-2 \Rightarrow y_1(-2) = x(2) = 1$
$n=-3 \Rightarrow y_1(-3) = x(3) = 1$
$n=-4 \Rightarrow y_1(-4) = x(4) = 0$



folding

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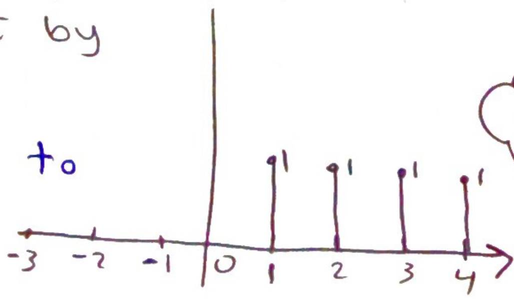
② $y_2(n) = x(n-1)$

$n=0 \Rightarrow y_2(0) = x(-1) = 0$
$n=1 \Rightarrow y_2(1) = x(0) = 1$
$n=2 \Rightarrow y_2(2) = x(1) = 1$
$n=3 \Rightarrow y_2(3) = x(2) = 1$
$n=4 \Rightarrow y_2(4) = x(3) = 1$
$n=5 \Rightarrow y_2(5) = x(4) = 0$
$\vdots \quad \downarrow 0$

$n=-1 \Rightarrow y_2(-1) = x(-2) = 0$
$n=-2 \Rightarrow y_2(-2) = x(-3) = 0$
$\vdots \quad \downarrow 0$

Delay by one sample
= Shift to right by one sample

$x(n-k)$ = Shift to right by k samples

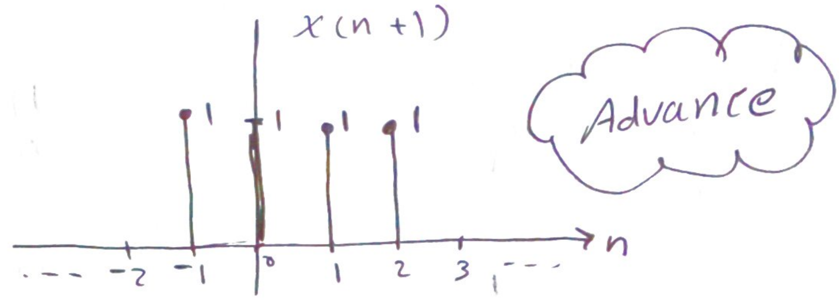


delay

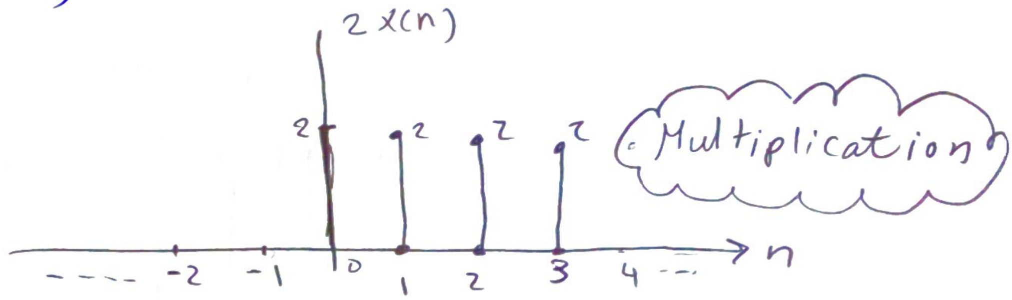
(3) $y_3(n) = x(n+1)$

Shift to left by one sample

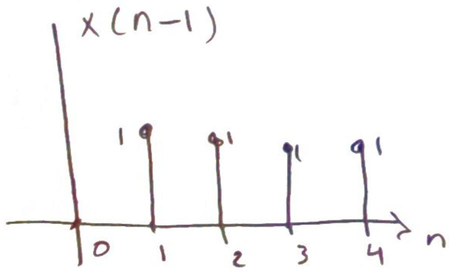
$x(n+k) \Rightarrow$ Shift to Left by k samples



(4) $y_4(n) = 2x(n)$



(5) $y_5(n) = x(n-1) + x(n+1)$



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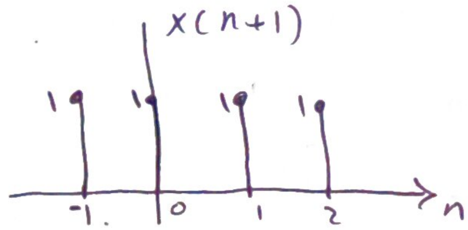
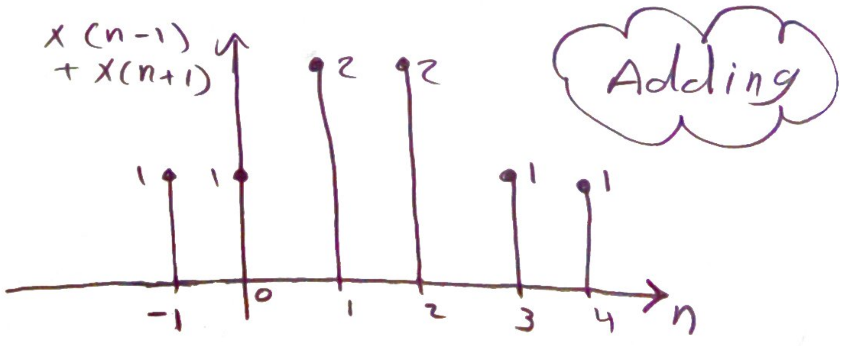


$\Rightarrow$



Ex: $x(n) = \{ 1/3, 2/3, \underset{\uparrow}{1}, 1, 1, 1 \}$

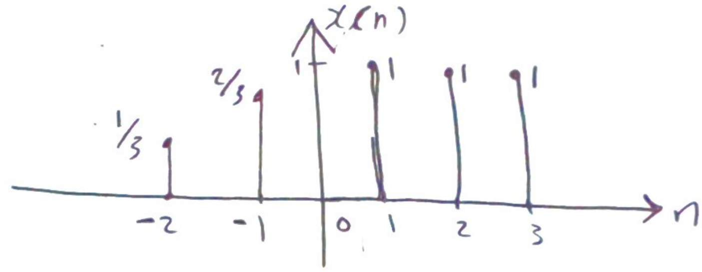
① - sketch $x(n)$

② - fold $x(n)$ and then delay by 4 samples

③ - delay $x(n)$ by 4 samples then fold

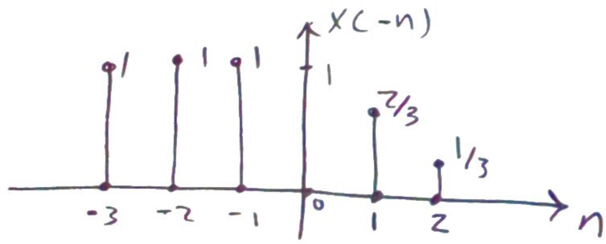
Solution

①

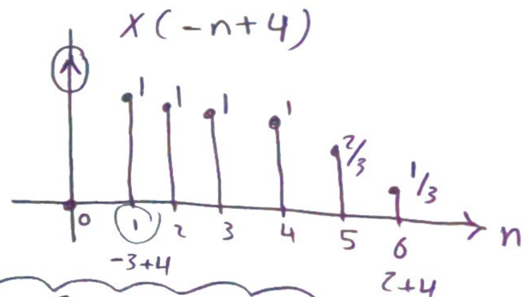


②

fold



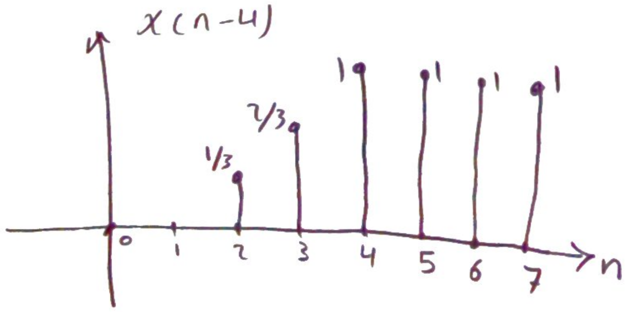
delay by 4 samples



الفقرة الثانية تكافئ إثبات $x(-(n-4))$

③

delay by 4 samples



fold